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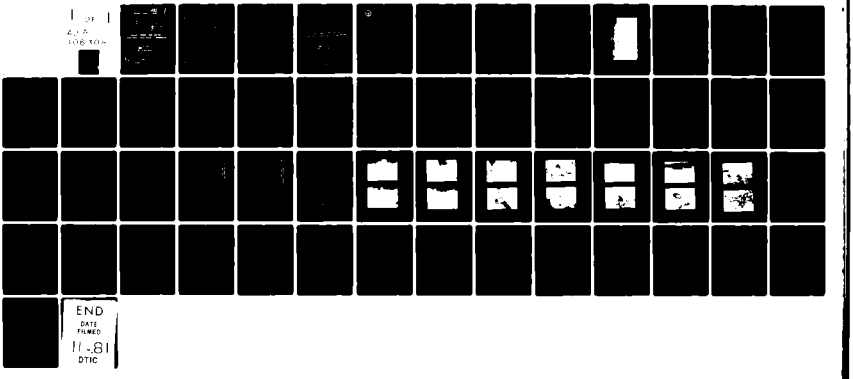

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ODD FELLOWS HOME LAKE DAM

CLAY COUNTY, MISSOURI

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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
Serving the Army
Serving the Nation

St. Louis District

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PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER	2. GOVT ACCESSION NO. / 3. RECIPIENT'S CATALOG NUMBER
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Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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ODD FELLOWS HOME LAKE DAM

CLAY COUNTY, MISSOURI

MO 11022

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
Serving the Army
Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT. ST. LOUIS

FOR: STATE OF MISSOURI

MAY 1980

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

LMSED-PD

SUBJECT: Odd Fellows Home Lake Dam, MO. I.D. No. 11022
Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Odd Fellows Home Lake Dam.

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency due to a seriously inadequate spillway by the St. Louis District as a result of the application of the following criteria:

a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: _____ _____
Chief, Engineering Division Date

APPROVED BY: _____ _____
Colonel, CE, District Engineer Date

ODD FELLOWS HOME LAKE DAM

CLAY COUNTY, MISSOURI

MISSOURI INVENTORY NO. 11022

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF

ST. LOUIS DISTRICT CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

MAY 1980

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Odd Fellows Home Lake Dam
State Located	Missouri
County Located	Clay County
Stream	Town Branch of Shoal Creek
Date of Inspection	8 May 1980

Odd Fellows Home Lake Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure would threaten lives and property. The estimated damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are a waterworks with appurtenant structures, seven dwellings, a building, and twelve trailers homes. Contents of the downstream damage zone were verified by the inspection team.

Our inspection and evaluation indicates the spillways do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillways will pass neither 50 nor 100 percent of the probable maximum flood without overtopping but will pass 10 percent of the probable maximum flood. The spillway will not pass the flood which has a one percent chance of occurrence in any given year (100-year flood). The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. Considering the small volume of water impounded behind the dam, the presence of an embankment in the valley below the dam, and the hazard zone, the spillway design flood should be 50 percent of the probable maximum flood. The probable maximum flood is defined as the flood discharge which may be expected from the most severe combination of critical meteorologic and hydrologic conditions which are reasonably possible in the region.

Based on visual observations, this dam appears to be in satisfactory condition. Deficiencies visually observed by the inspection team were extremely dense grass, tree, and brush cover, irregular surfaces of

the crest and side slopes, seepage at the toe of the right abutment, erosion at the left abutment, the presence of a leaking sewer line near the left abutment, and the absence of adequate slope protection on the upstream face. Seepage and stability analyses required by the guidelines were not available.

There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.

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Harry L Callahan

Harry L. Callahan, Partner
Black & Veatch

OVERVIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
ODD FELLOWS HOME LAKE DAM

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APPENDIX

Appendix A - Hydrologic and Hydraulic Analyses

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Odd Fellows Home Lake Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. *Description of Dam and Appurtenances.*

(1) The dam is an earth structure located in the valley of the Town Branch of Shoal Creek (see Plate 1). The watershed area is hilly consisting of farmland and Odd Fellows Home facilities (see Plate 2). The dam is approximately 440 feet long along the crest and 23 feet high. The dam crest is 9 feet wide. The downstream face of the dam has a fairly uniform slope from the crest to the valley floor below.

(2) The primary spillway from the lake is an uncontrolled 24-inch steel pipe with antivortex plate installed in the embankment. Flow through the pipe discharges into a basin confined by the subject embankment and what is believed by the inspection team to be a haul road embankment with a 24-inch reinforced concrete pipe through the embankment which discharges to the natural stream channel below. The emergency spillway consists of a triangular cut in the natural overburden and embankment. Discharge through the emergency spillway overflows to the same basin as does the primary spillway.

(3) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in south-central Clay County, Missouri, as indicated on Plate 1. The lake formed by the dam is

shown on the United States Geological Survey 7.5 minute series quadrangle map for Liberty, Missouri in Section 17 of T51N, R31W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the small size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Odd Fellows Home Lake Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For the Odd Fellows Home Lake Dam the estimated flood damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are a waterworks with appurtenant structures, seven dwellings, a building, and twelve trailer homes. Contents of the downstream damage zone were verified by the inspection team.

e. Ownership. The dam is owned by the Odd Fellows Home Association, Inc., Route 6 Box 194, Liberty, Missouri 64068, Telephone 816-781-4880.

f. Purpose of Dam. The dam forms a 6-acre lake used for recreation.

g. Design and Construction History. According to Helen White, Administrator, the dam is nearly 100 years old. No specific date, design, nor construction data were available.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, evaporation, and overflow through the uncontrolled outlet pipe all combine to maintain a relatively stable water surface elevation.

1.3 PERTINENT DATA

a. Drainage Area - 487 acres

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled 24-inch outlet pipe which discharges to an area between the dam and a haul road embankment through which a 24-inch reinforced concrete pipe discharges to the natural stream channel below.

(2) Estimated experienced maximum flood at damsite - Unknown.

(3) Estimated ungated spillway capacity at maximum pool elevation 730 cfs (50 Percent Probable Maximum Flood Pool El.781.5).

c. Elevation (Feet above m.s.l.).

(1) Top of dam - 779.5 (see Plate 3)

(2) Emergency spillway crest - 777.8

(3) Primary spillway pipe invert - 775.0

(4) Streambed at toe of dam - 756.7

(5) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 1,300 feet ± (50 Percent probable maximum flood pool level)

(2) Length of normal pool - 1,000 feet ± (Primary spillway pipe invert)

e. Storage (Acre-feet).

(1) Top of dam - 64

(2) Emergency spillway crest - 50

(3) Primary spillway pipe invert - 32

(4) Design surcharge - Not available.

f. Reservoir Surface (Acres).

(1) Top of dam - 9

(2) Emergency spillway crest - 6.8

(3) Primary spillway pipe invert - 6.3

g. Dam.

(1) Type - Earth embankment

(2) Length - 440 feet

(3) Height - 23 feet ±

(4) Top width - 9 feet

(5) Side slopes - upstream face 1.0 V on 2.6 H, downstream face between 1.0 V on 2.0 H and 1.0 V on 2.4 H (see Plate 4)

(6) Zoning - Unknown.

(7) Impervious core - Unknown.

(8) Cutoff - Unknown.

(9) Grout curtain - Unknown.

h. Diversion and Regulating Tunnel - None.

i. Primary Spillway.

(1) Type - 24-inch steel pipe with antivortex plate.

(2) Inlet invert elevation - 775.0 feet m.s.l.

(3) Outlet invert elevation 758.7 feet m.s.l.

(4) Gates - None.

(5) Upstream channel - Not applicable.

(6) Downstream channel - An earth embankment is present immediately downstream of the primary spillway outlet which has a 24-inch concrete pipe to discharge to the natural open channel below.

j. Emergency Spillway.

(1) Type - Grass open channel.

(2) Width of channel - 86 feet.

(3) Emergency spillway crest - 777.8

(4) Gates - None.

(5) Upstream channel - Not applicable.

(6) Downstream channel - A haul road embankment is constructed in the valley immediately downstream of the dam. A 24-inch reinforced concrete pipe runs beneath the haul road embankment which permits primary and emergency spillway discharges to discharge downstream of the haul road to the natural channel.

k. Regulating Outlets - None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design data were not available.

2.2 CONSTRUCTION

Construction records were unavailable.

2.3 OPERATION

Records of operation or of past floods were not available.

2.4 GEOLOGY

The site of the dam and reservoir is located in a broad shallow valley in gently rolling terrain. The dam is located on Town Branch of Shoal Creek.

The soil of the dam and reservoir area consists of the Sibley soil series. The Sibley series consists of deep, well-drained soils formed in loess on convex ridges and side slopes. The general depth of bedrock is greater than five feet. The soil is classified for engineering purposes as a low plastic clay (CL).

The bedrock of the dam and reservoir area consists of the Wyandotte formation of the Kansas City Group. The Wyandotte formation is composed of five members. These are, from the base upwards, the Frisbie, Quindaro, Argentine, Island Creek, and Farley members. The Frisbie, Argentine, and Farley members are composed of limestone and are separated by the Quindaro calcareous shale and the Island Creek shale, respectively.

2.5 EVALUATION

a. Availability. No engineering data were available.

b. Adequacy. No engineering data were available. Thus, an assessment of the design, construction, and operation could not be made. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity. The validity of the design, construction, and operation could not be determined due to the lack of engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Odd Fellows Home Lake Dam was made on 8 May 1980. The inspection team included professional engineers with experience in dam design and construction, hydrology, hydraulic engineering, and geotechnical engineering. The inspection team consisted of Edwin Burton, team leader; Robert Pinker, geologist; Gary Van Riessen, geotechnical engineer; John Ruhl, hydrologist/hydraulic engineer; Mark Snyder, hydrologist/hydraulic engineer; and Russell Burnham, structural engineer. The dam is in satisfactory condition. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following conditions at the dam. The crest of the dam is narrow and irregular. The upstream and downstream slopes are steep and of irregular slope. The upstream face has no riprap slope protection. Extremely dense tree, grass, and brush cover is typical of the embankment. Seepage of approximately 1 gpm was observed at the toe of the embankment at the right abutment. Erosion of embankment material was observed at the left abutment. A 12-inch sewer line and manhole on the downstream face near the left abutment was observed leaking raw sewage. It is evident that the sewer line is beneath the lake and embankment, although the line could not be observed. Flow in the sewer line was approximately 1/2 pipe flow. Typical of the embankment was trampled grass and brush which indicates probable animal activity. No animal burrows could be observed due to the dense vegetation on the embankment. The embankment material consisted of silty clay (CL). The embankment has no visible stability problems. There was no evidence to indicate that the embankment has been overtopped.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. The primary spillway consists of a 24-inch beveled steel pipe with antivortex plate which runs through the embankment. Several feet of the pipe which were observable at each end appeared to be in good condition. An earth embankment is constructed immediately below the primary spillway outlet. A 24-inch concrete pipe permits discharge through the downstream embankment at an elevation close to the primary spillway outlet. The inspection team speculates that the embankment was constructed as a haul road for earth fill for the nearby highway. The emergency spillway consisted of a triangular cut in the natural overburden and dam at the right abutment. There are no existing toe drains or relief wells.

d. Geology. The soil on the slopes around the reservoir and below the dam is formed in loess. No outcrops of rocks are present in the vicinity of the dam and reservoir. The depth to rock is estimated to be greater than twenty feet.

Samples of the embankment material were taken near the downstream crest on the left side of the embankment with an Oakfield sampler. The first two feet consisted of soft, moist silty clay with some organic matter. The next two feet were the same material except that it was firm and dry. The samples were visually classified in accordance with ASTM D 2488-69. Based on these samples, it is anticipated that the embankment consists of silty clay of low plasticity.

The abutments and foundation of the embankment are anticipated to be interbedded limestone and shale of the Wyandotte formation overlain by the Sibley soil series. These interpretations are based on visual observations and published data.

e. Reservoir Area. No slides or excessive erosion due to wave action were observed along the shore of the reservoir. It appeared at the time of the inspection that the lake has considerable siltation which may be attributed to recent highway construction within the drainage basin.

f. Downstream Channel. Downstream of the spillway outlet pipe is a haul road embankment with a culvert beneath the embankment which discharges to the original streambed.

3.2 EVALUATION

The various deficiencies observed at the time of the inspection are not believed to represent an immediate safety hazard. They do, however, warrant monitoring and control. The 12-inch sewer within the embankment near the left abutment does not in itself constitute a deficiency. However, the leakage of raw sewage from the sewer and manhole near the left abutment contributes to erosion and saturation of embankment material. The potential for sloughing, erosion, or sliding of embankment material is enhanced by the presence of the relatively steep side slopes and the narrow, irregular crest. The growth of trees and brush and the uncut grass, if allowed to go unchecked, could cause deterioration of the embankment. The roots of trees can loosen the embankment material and also can leave voids through which water can pass. Brush on the dam prevents inspection of the embankment and kills the smaller grasses whose roots are more effective in protecting the surface soil of the slope from erosion. The brush and tall uncut grass provides habitat for burrowing animals which can damage the embankment. The area of seepage at the toe of the dam at the right abutment which was observed should be

monitored regularly for quality and quantity. Seepage can cause internal erosion creating cavities and underground channels, thereby weakening the embankment and/or abutments.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, evaporation, transpiration, and capacity of the uncontrolled primary spillway outlet pipe.

4.2 MAINTENANCE OF DAM

No maintenance was evident.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no existing warning system or preplanned scheme for alerting downstream residents for this dam.

4.5 EVALUATION

A maintenance program should be initiated which would include mowing the grass cover on the embankment in order to discourage animal burrowing. The brush and trees on the embankment should be removed. The area of seepage should be monitored periodically and, if flow increases significantly or if seepage flow becomes muddy, a qualified engineer should be consulted.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. No design data were available.

b. Experience Data. The drainage area and lake surface area are developed from USGS Liberty Quadrangle Map. The dam layout is from a survey made during the inspection.

c. Visual Observations.

(1) The primary spillway appears to be in good condition. The lake level at the time of the inspection was below the inlet level and there was no flow through the pipe. Only the inlet and outlet ends were observable. Flow through the primary spillway pipe discharges into a basin confined by the subject embankment and what is believed by the inspection team to be a haul road embankment with a 24-inch reinforced concrete pipe through the embankment which discharges to the natural stream channel below. There were no obstructions to flow in the channel downstream of the haul road embankment.

(2) The emergency spillway channel is in good condition with no evidence of erosion at the time of the inspection.

(3) Spillway discharges do not endanger the integrity of the dam.

d. Overtopping Potential. The spillways will not pass the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillways will pass 10 percent of the probable maximum flood without overtopping the dam. The spillways will not pass the one percent chance flood estimated to have a peak outflow of 545 cfs developed by a 48-hour, one percent chance rainfall. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Considering the small volume of water impounded by the dam, the presence of an embankment in the valley below the dam, and the downstream hazard, the appropriate spillway design flood should be 50 percent of the probable maximum flood. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 770 cfs of the total discharge from the reservoir of 1,500 cfs. The estimated duration of overtopping is 6.3 hours with a maximum height of 1.2 feet. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 2,040 cfs of the total discharge from the reservoir of 3,000 cfs. The estimated duration of

overtopping is 8.8 hours with a maximum height of 2.0 feet. The embankment could be jeopardized should overtopping occur for these periods of time.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately two miles downstream of the dam. A waterworks with appurtenant structures, seven dwellings, twelve trailer homes, and a building could be severely damaged and lives could be lost should failure of the dam occur. Contents of the estimated downstream damage zone were verified by the inspection team.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. No design data relating to the structural stability of the dam were found. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Operating Records. No operational records exist.

d. Postconstruction Changes. An embankment has been constructed in the valley immediately below the dam. The inspection team speculates that the embankment served as a haul road for highway fill. A 24-inch reinforced concrete culvert allows primary spillway discharges to flow beneath the haul road embankment.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone. The seismic stability of an earth dam is dependent upon a number of factors: embankment and foundation material classifications and shear strengths; abutment materials, conditions, and strengths; embankment zoning; and embankment geometry.

Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several conditions observed during the visual inspection by the inspection team should be monitored and/or controlled. These are erosion of the left abutment, seepage from the right abutment at the embankment toe, the dense growth of grass, brush, and trees on the embankment, and the leakage of raw sewage from the sewer line near the left abutment. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

b. Adequacy of Information. Due to the absence of engineering design data, the conclusions in this report were based only on performance history and visual conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. A program should be developed as soon as possible to monitor at regular intervals the deficiencies described in this report. The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. The item recommended in paragraph 7.2a should be pursued on a high priority basis.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam nor does it identify any serious dangers which would require a Phase II investigation. However, the additional analyses noted in paragraph 2.5b are necessary for compliance with the guidelines.

e. Seismic Stability. This dam is located in Seismic Zone 1. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

7.2 REMEDIAL MEASURES

a. Alternatives. The emergency spillway size and/or height of the dam would need to be increased or the lake level would need to be lowered to increase available flood storage in order to pass the spillway design flood. The emergency spillway should be protected to prevent erosion.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended and should be implemented under the direction of a professional engineer experienced in the design, construction, and maintenance of earth dams.

(1) Riprap should be placed on the upstream face of the dam at the normal lake level to prevent erosion of the embankment material.

(2) The seepage area noted during the visual inspection should be closely monitored and documented as to quantity of flow. Any significant changes should be evaluated.

(3) An improved maintenance program to remove and control the growth of brush and trees on the embankment should be developed. Grass cover on the embankments should be cut periodically.

(4) The sewer line near the left abutment should be repaired to eliminate leakage of sewage.

(5) A trash rack should be added to the primary spillway inlet.

(6) Seepage and stability analysis should be performed.

(7) A detailed inspection of the dam should be made periodically. This inspection should include measurement of seepage flows and analyzing water samples taken from the seep and lake. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increase.

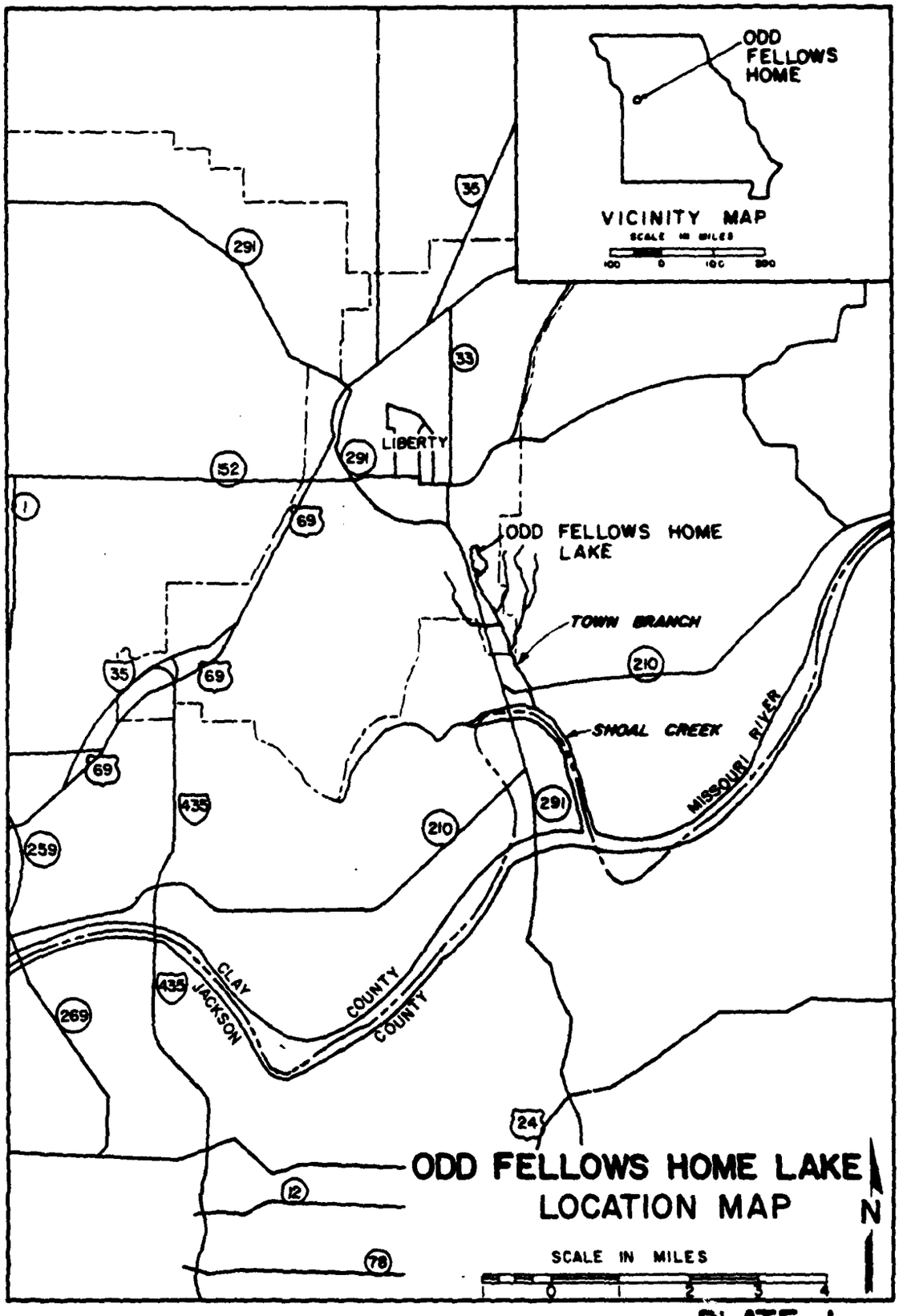

ODD FELLOWS HOME
VICINITY MAP
SCALE IN MILES
100 0 100 200
35
291
33
LIBERTY
291
152
1
69
ODD FELLOWS HOME LAKE
TOWN BRANCH
210
35
69
SMOAL CREEK
MISSOURI RIVER
69
435
291
210
259
435
CLAY COUNTY
JACKSON COUNTY
269
24
12
78
ODD FELLOWS HOME LAKE
LOCATION MAP
N
SCALE IN MILES
0 1 2 3 4

PLATE 1

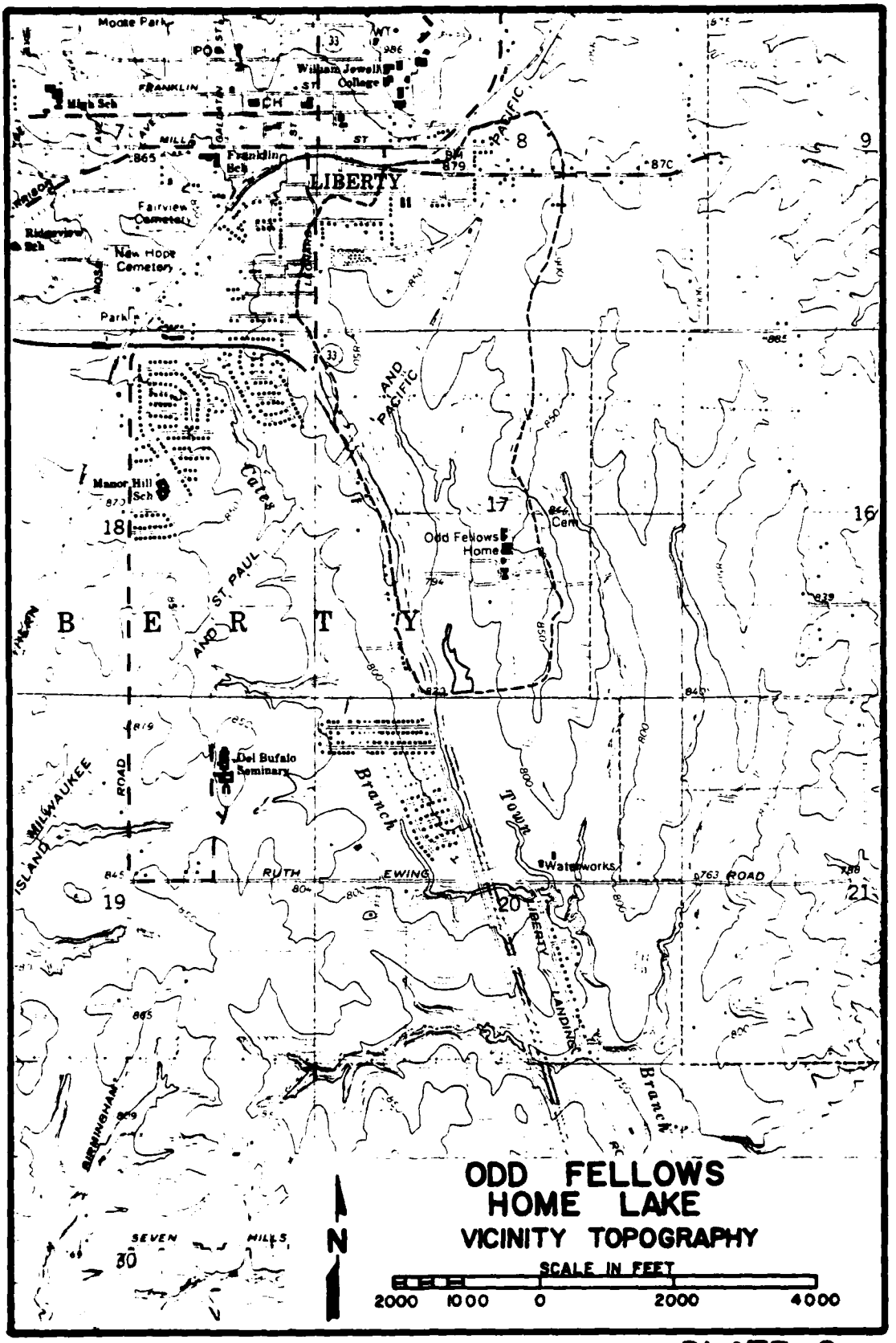

Moose Park
William Jewell College
Franklin Sch
LIBERTY
Fairview Cemetery
New Hope Cemetery
Riverview Sch
Park
PACIFIC
AND
ST. PAUL
Manor Hill Sch
Odd Fellows Home
Cem
BERTY
Del Bufalo Seminary
MILWAUKEE
ISLAND
ROAD
Branch
Town
Waterworks
RUTH
EWING
763 ROAD
LIBERTY LANDING
Branch
BIRMINGHAM
SEVEN HILLS
N
ODD FELLOWS
HOME LAKE
VICINITY TOPOGRAPHY
SCALE IN FEET
2000 1000 0 2000 4000

PLATE 2

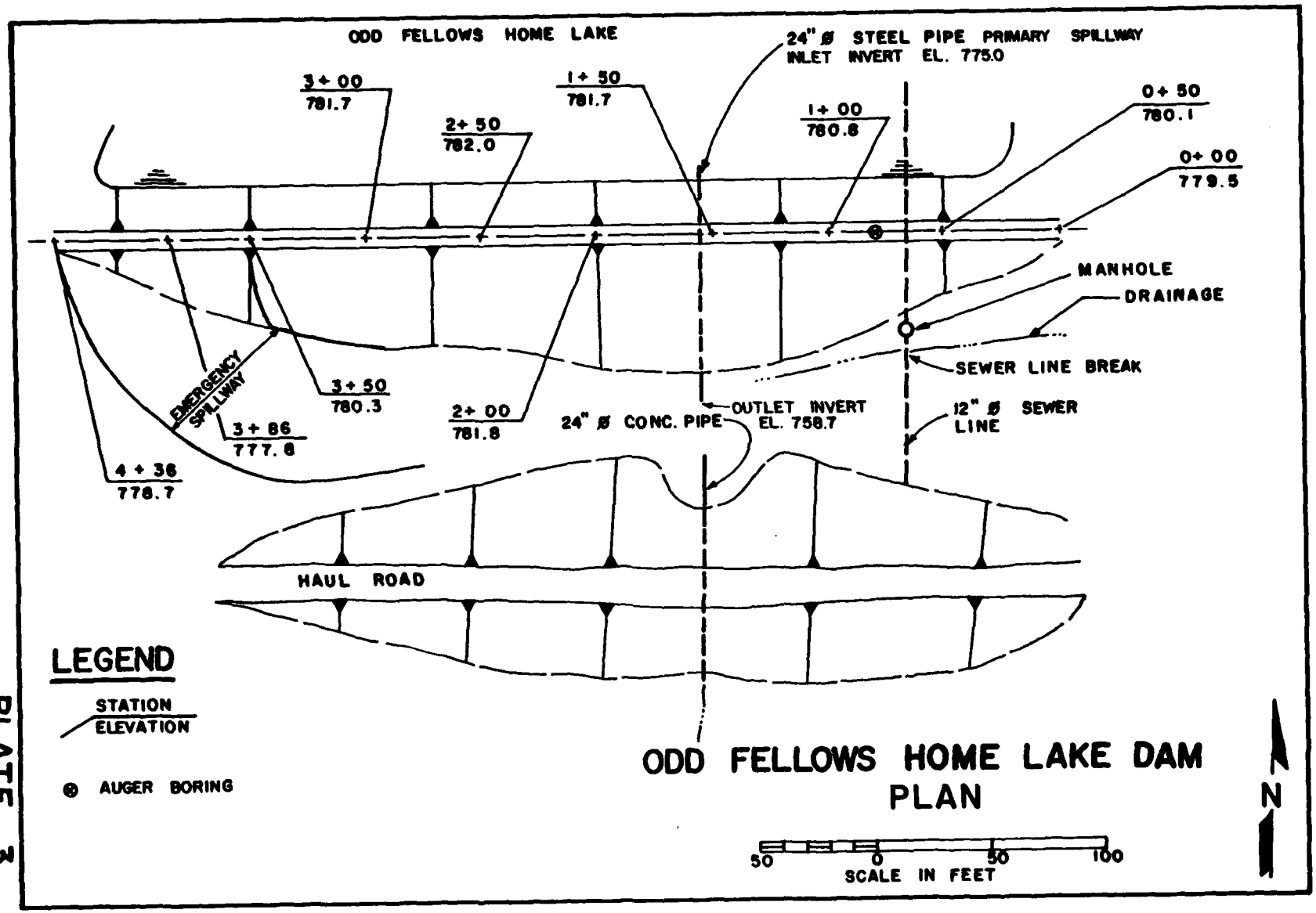

ODD FELLOWS HOME LAKE
24" ø STEEL PIPE PRIMARY SPILLWAY
INLET INVERT EL. 775.0
3+00
781.7
2+50
782.0
1+50
781.7
1+00
780.8
0+50
780.1
0+00
779.5
MANHOLE
DRAINAGE
SEWER LINE BREAK
EMERGENCY SPILLWAY
3+50
780.3
3+86
777.8
2+00
781.8
24" ø CONC. PIPE
OUTLET INVERT
EL. 758.7
12" ø SEWER
LINE
4+36
778.7
HAUL ROAD
LEGEND
STATION
ELEVATION
AUGER BORING
ODD FELLOWS HOME LAKE DAM
PLAN
N
50
0
50
100
SCALE IN FEET

PLATE 3

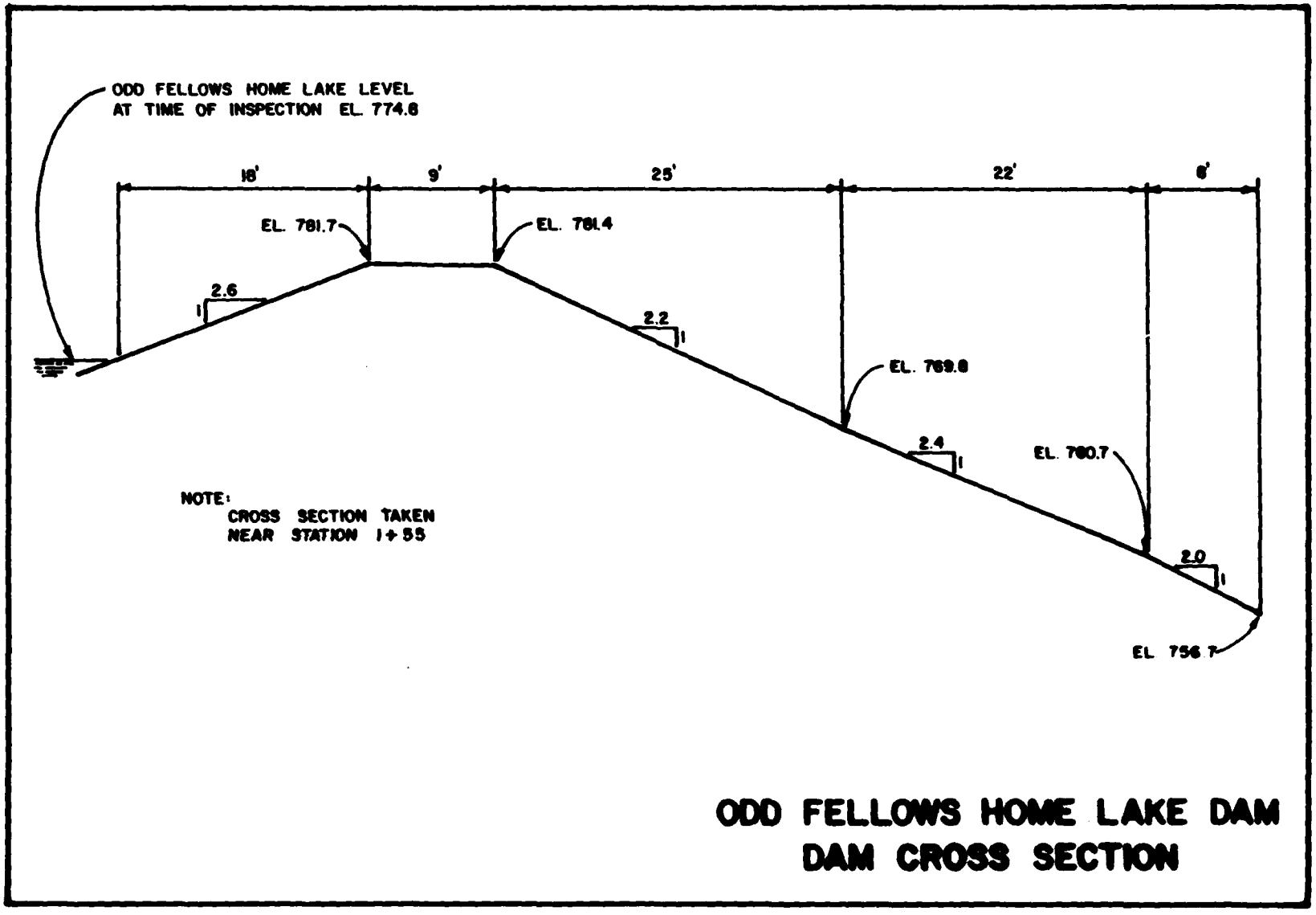
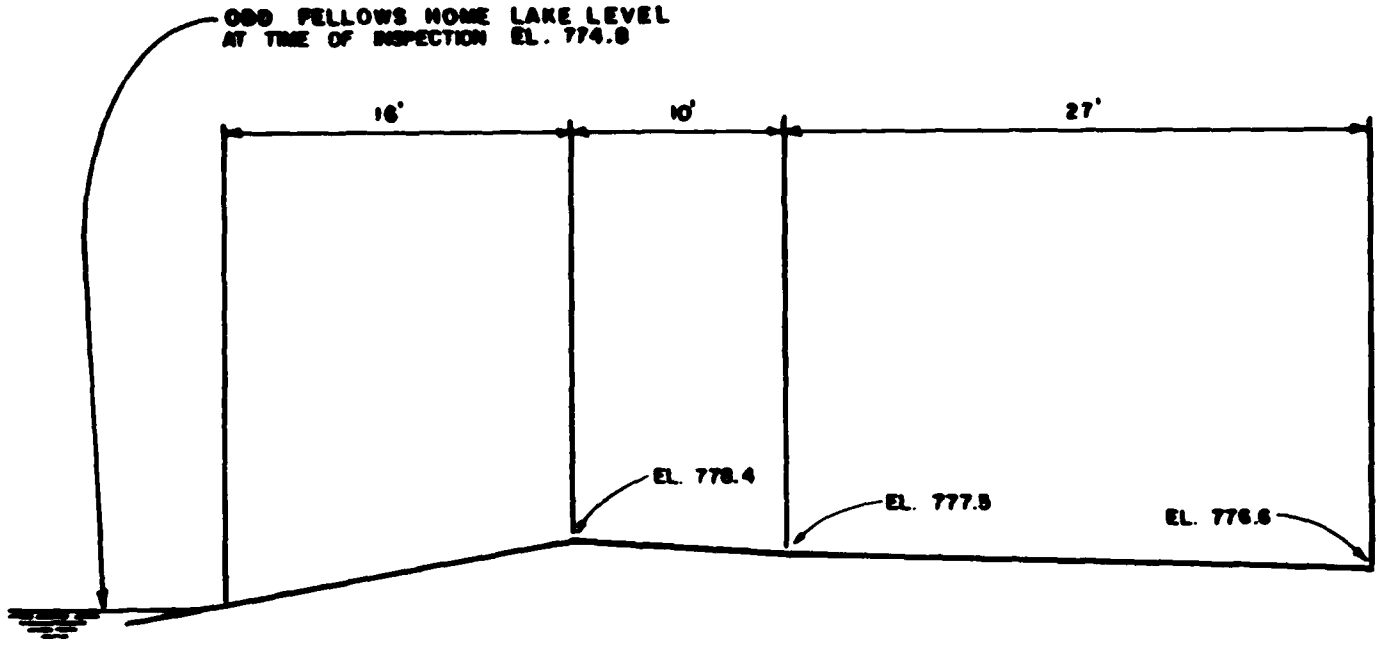


PLATE 4

ODD FELLOWS HOME LAKE DAM
DAM CROSS SECTION



NOTE:
CROSS SECTION TAKEN
NEAR STATION 4 + 00

PLATE 6

ODD FELLOWS HOME LAKE DAM
EMERGENCY SPILLWAY PROFILE

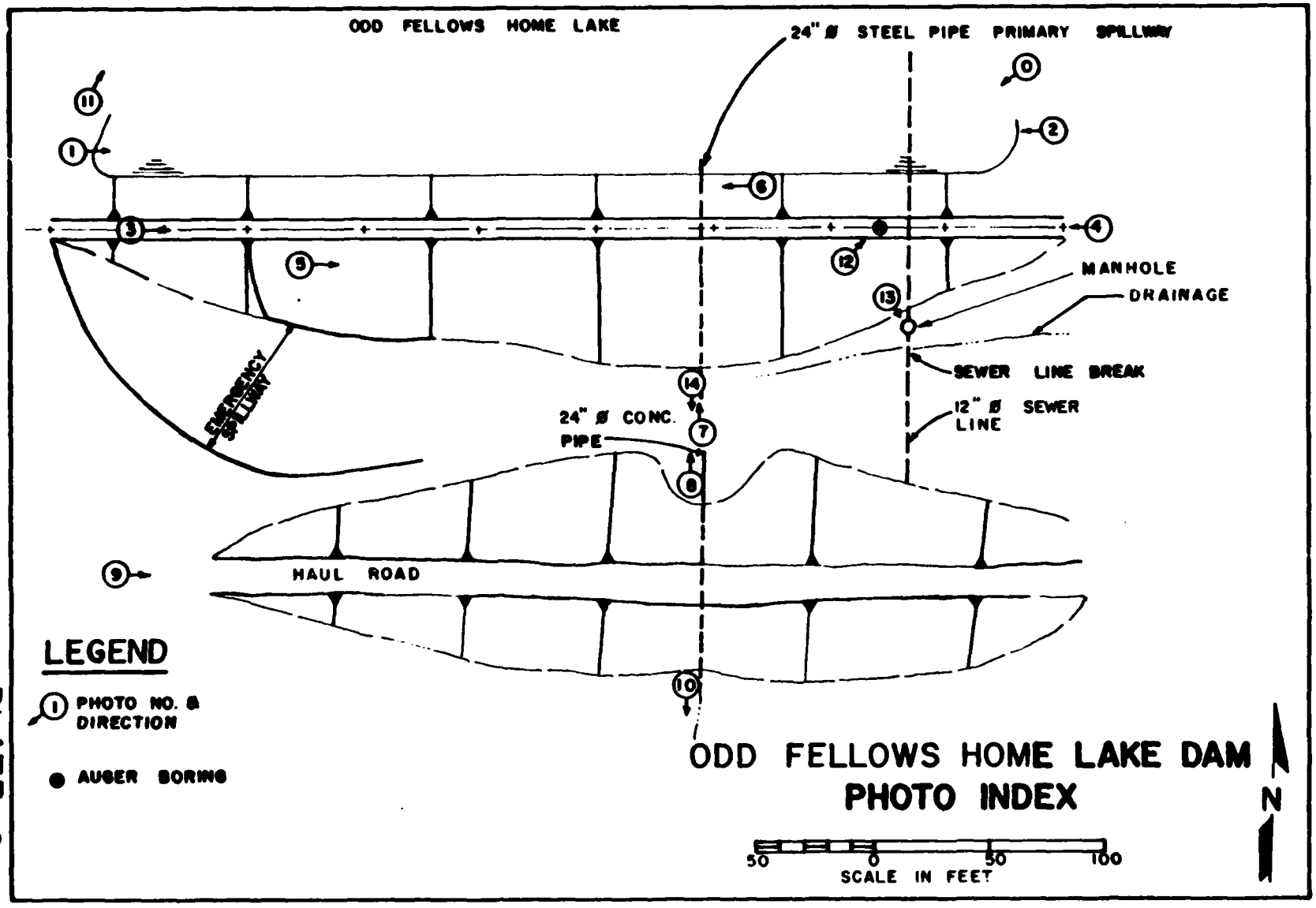

ODD FELLOWS HOME LAKE
24" ø STEEL PIPE PRIMARY SPILLWAY
MANHOLE
DRAINAGE
SEWER LINE BREAK
12" ø SEWER LINE
24" ø CONC. PIPE
EMERGENCY SPILLWAY
HAUL ROAD
LEGEND
PHOTO NO. & DIRECTION
AUGER BORING
ODD FELLOWS HOME LAKE DAM
PHOTO INDEX
N
50 0 50 100
SCALE IN FEET

PLATE 6

PHOTO 1: FACE OF DAM LOOKING EAST

PHOTO 2: FACE OF DAM LOOKING WEST

PHOTO 3: CREST OF DAM LOOKING EAST

PHOTO 4: CREST OF DAM LOOKING WEST

PHOTO 5: TYPICAL VIEW OF BACK SLOPE OF DAM

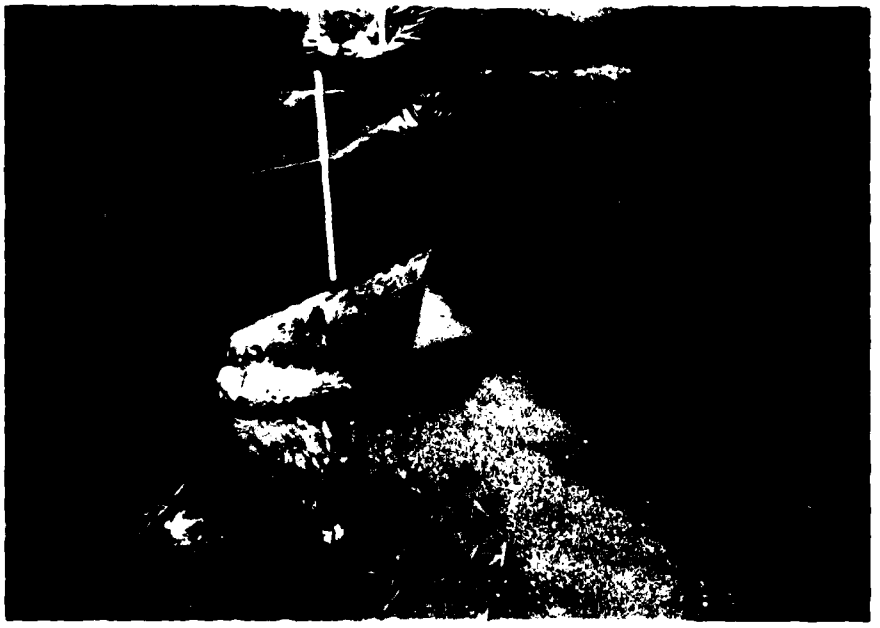


PHOTO 6: PRIMARY SPILLWAY INLET

PHOTO 7: PRIMARY SPILLWAY OUTLET

PHOTO 8: OUTLET OF PRIMARY SPILLWAY AND INLET TO PIPE THROUGH LOWER EMBANKMENT

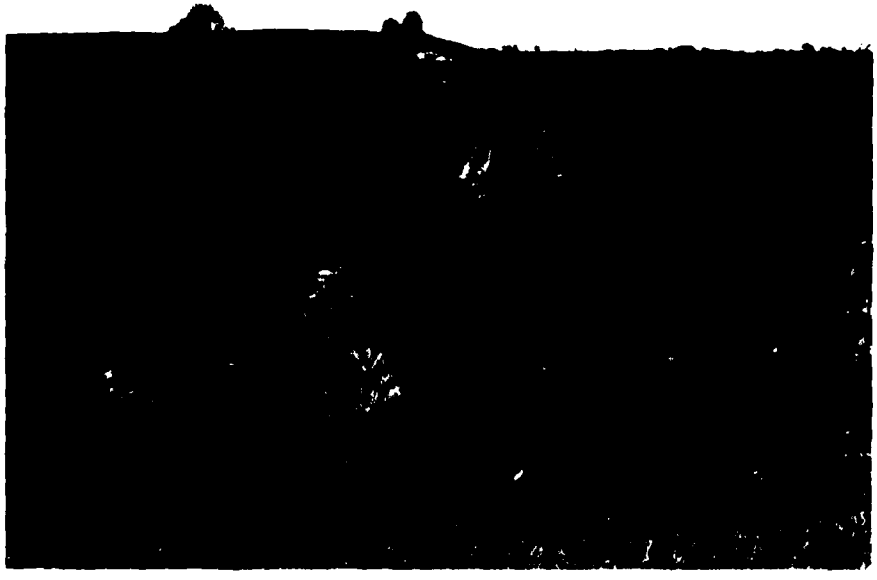


PHOTO 9: OVERVIEW OF LOWER EMBANKMENT

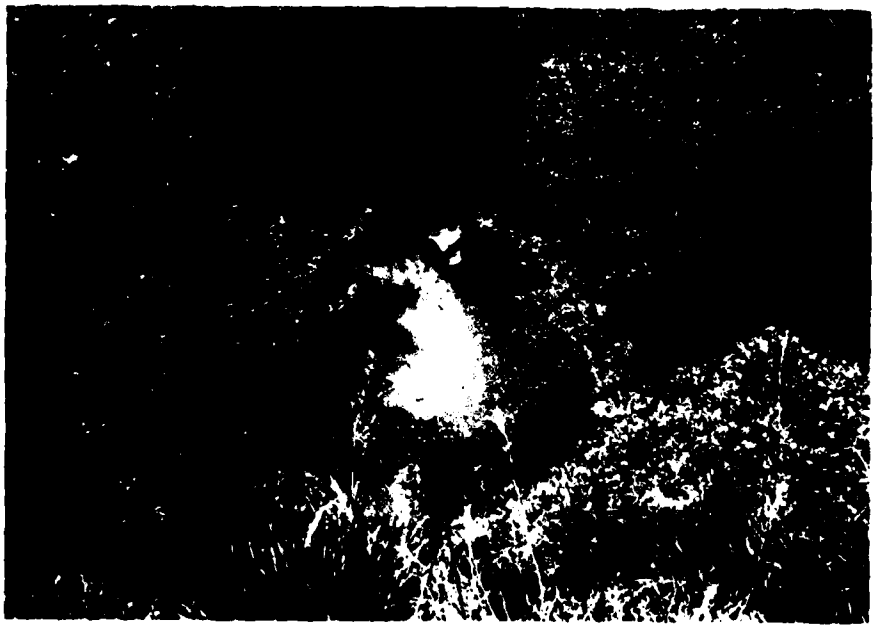


PHOTO 10: CHANNEL BELOW LOWER EMBANKMENT

PHOTO 11: UPPER END OF ODD FELLOWS HOME LAKE

PHOTO 12: SAMPLE OF EMBANKMENT MATERIAL

PHOTO 13: SEWER MANHOLE ON DOWNSTREAM SIDE OF DAM

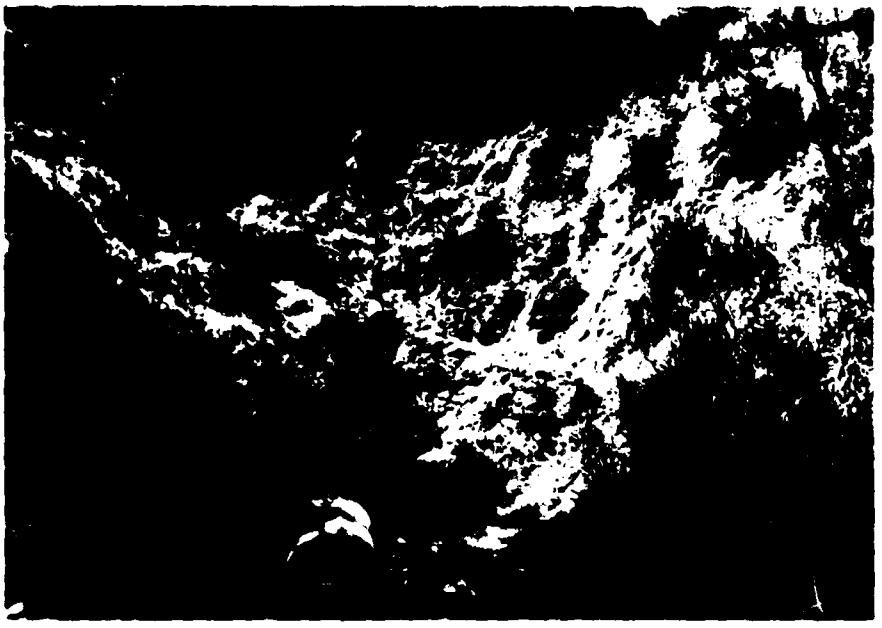


PHOTO 14: EROSION AT LOWER EMBANKMENT

APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC ANALYSES

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was determined using the computer program HEC-1 (Dam Safety Version) (1).

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33" (HMR-33). Reduction factors were not applied. The rainfall distribution for the 48-hour PMP storm was determined according to the procedures outlined in HMR-33 and EM 1110-2-1411. The Kansas City, Missouri rainfall distribution (15 min. interval - 48 hours duration), as provided by the St. Louis District, Corp of Engineers, was used when the one percent chance probability flood was routed through the reservoir and spillway.

The synthetic unit hydrograph for the watershed was developed by the computer program using the Soil Converation Service (SCS) method. The parameters for the unit hydrograph are shown in Table 1.

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationship. The CN values used, and the result from the computer output, are shown in Table 2.

The reservoir routing was performed using the Modified Puls Method. The initial reservoir pool elevation for the routing of each storm was determined to be equivalent to the pipe invert elevation of the primary spillway at elevation 775.0 feet m.s.l. in accordance with antecedent storm conditions preceding the one percent probability and probable maximum storms outlined by the U.S. Army Corps of Engineers, St. Louis District (5). The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation, surface area, storage, and discharge relationships shown in Table 3.

The rating curve for the spillways is shown in Table 4. The flow over the crest of the dam and emergency spillway was determined using the non-level dam crest option ($L and $V cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir. The flow through the primary spillway was determined from the orifice flow equation and nomographs for partial flow in the pipe.

The result of the routing analyses indicates that 10 percent of the PMF will not overtop the dam.

A summary of the routing analysis for different ratios of the PMF is shown in Table 5.

The computer input data and a summary of the output data are presented at the back of this appendix.

TABLE 1

SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	487 acres	
Hydraulic Length of Watercourse (ℓ)	7,400 feet	
Hydrologic Soil Cover Complex Number (CN')	87 (AMC III)	73 (AMC II)
Average Watershed Land Slope (Y)	1.68%	
Lag Time (L_g)	1.49 hours (AMC III)	2.45 hours (AMC II)
Time of concentration (T_c)	2.48 hours (AMC III)	4.08 hours (AMC II)
Duration (D)	20 min. (AMC III) (use 15 minutes in each case)	33 min. (AMC II)

Time (Min.) *	Discharge (cfs) * AMC II	AMC III
0	0	16
15	17	46
30	32	94
45	52	157
60	79	205
75	108	226
90	131	226
105	146	206
120	153	179
135	153	142
150	148	104
165	137	81
180	125	63
195	110	50
210	92	39

* From HEC-1 computer output

TABLE 1
(Continued)

FORMULAS USED:

$$L_g = \frac{l^{0.8} \times (S + 1)^{0.7}}{1{,}900 \times Y^{0.5}} \qquad (4)$$

$$S = \frac{1000}{CN' - 10}$$

$$T_c = L_g / 0.6$$

$$D = 0.133\ T_c$$

TABLE 2

RAINFALL-RUNOFF VALUES

Selected Storm Event	Storm Duration (Hours)	Rainfall (Inches)	Runoff (Inches)	Loss (Inches)
PMP	48	34.44	32.71	1.73
1% Probability	48	6.00	3.09	2.91

Additional Data:

1) The soil associations in this watershed are Macksburg, Sibley, and Sharpsburg (3).
   100 percent of drainage area in hydrologic soil group B.
   30 percent of the land use was urban.
   60 percent of the land use was cropland.
   10 percent of the land use was timberland (2 and 4).
2) SCS Runoff Curve CN = 87 (AMC III) for the PMF.
3) SCS Runoff Curve CN = 73 (AMC II) for the one percent probability flood.

TABLE 3

ELEVATION, SURFACE AREA, STORAGE, AND DISCHARGE RELATIONSHIPS

Elevation (feet-MSL)	Lake Surface Area (acres)	Lake Storage (acre-ft)	Spillway Discharge (cfs)
*775.0	6.3	32	0
**777.8	6.8	50	58
***779.5	9.0	64	377

*Primary spillway pipe invert elevation
**Emergency spillway crest elevation
***Top of dam elevation

The relationships in Table 3 were developed from the Liberty, Missouri. 7.5 minute quadrangle map and the field measurements.

TABLE 4

SPILLWAY RATING CURVE

Reservoir Elevation (ft-msl)	Primary Spillway Discharge (cfs)	Emergency Spillway Discharge (cfs)	Total Spillway Discharge (cfs)
775.0	0	0	0
776.0	5	0	5
777.0	55	0	55
*777.8	58	0	58
778.0	58	2	60
**779.5	61	316	377

*Emergency Spillway Crest Elevation
**Top of Dam Elevation

METHOD USED:

Primary spillway release rates were based on the discharge calculated for flow through the pipe using the orifice equation:

$$Q = 2a[2gH]^{1/2}$$

where:

c = 0.45 = coefficient of discharge
a = 3.14 sq. ft_2 = net area of orifice
g = 32.2 ft/sec^2 = gravitational acceleration
H = difference between the energy gradient elevation upstream and the downstream tailwater elevation (6).

Discharge rates for a partially filled outlet pipe were determined by nomographs for pipe culverts with inlet control (7).

Emergency spillway releases were computed by HEC-1 from spillway geometry data input on $L and $V cards. The following equations were used in calculating the emergency spillway discharge:

$$d_c = 2/3\ (H_m + 1/4\Delta\ Y)$$

$$A = 1/2\ T\ (2d_c - \Delta\ Y)$$

$$Q = (A^3 g/T)^{0.5}$$

where:

d_c = critical depth (feet)

H_m = available specific energy which is taken to be the height of the water surface in the reservoir above the bottom of the section (feet)

ΔY = change in elevation across the section (feet)

A = flow area (sq. ft.)

T = top width (feet)

Q = flow (cfs)

g = 32.2 ft/sec^2 = acceleration due to gravity.

TABLE 5

RESULTS OF FLOOD ROUTINGS

Ratio of *PMF*	Peak Inflow *(CFS)*	Peak Lake Elevation *(ft.-MSL)*	Total Storage *(AC.-FT.)*	Peak Outflow *(CFS)*	Depth (ft.) Over Top of Dam
-	0	*775.0	32	0	-
0.10	300	779.3	61	293	0
0.50	1,498	780.7	72	1,498	1.2
1.00	2,996	781.5	79	2,996	2.0

* Primary spillway pipe invert elevation

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(1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.

(2) U.S. Department of Agriculture, Soil Conservation Service, Technical Release No. 55, Urban Hydrology for Small Watersheds, January, 1975.

(3) U.S. Department of Agriculture, Soil Conservation Service, Preliminary Soils Report for Clay County, Missouri.

(4) U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, August 1972.

(5) U.S. Army Corps of Engineers, St. Louis District, Hydrologic/ Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams, 12 December 1979.

(6) Horace W. King and Ernest F. Brater, Handbook of Hydraulics, Sixth Edition, McGraw Hill Book Company, 1976.

(7) U.S. Department of Commerce, Bureau of Public Roads, Hydraulic Engineering Circular No. 5, Hydraulic Charts for the Selection of Highway Culverts, December, 1965.

(8) U.S. Department of Agriculture, Soil Conservation Service, Soil Survey Interpretations and Field Maps, 1980.

(9) Mary H. McCracken, Missouri Division of Geological Survey, Geologic Map of Missouri, 1961.

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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
    1                 AIMISSOURI DAM INSPECTION PROGRAM
    2                 A2ST LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
    3                 A3ODD FELLOWS LAKE DAM
    4                 B    192       0      15       0       0       0       0       0       0       0
    5                 B1     5
    6                 J      1       7       1
    7                 J1   .05     .10     .15     .20     .25      .5     1.0
    8                 K      0       1                               3       1
    9                 K1   ODD FELLOWS LAKE (48 HR. PROBABLE MAXIMUM RUNOFF)
   10                 M      1       2    .761                               1
   11                 P             24.60     101     120     130     140
   12                 T                                                     -1     -87
   13                 W2          1.49
   14                 X                     1
   15                 X      1       2                                      1
   16                 K1   ROUTING THROUGH SPILLWAY
   17                 Y                                     1       1
   18                 Y1     1                                             -775.      -1
   19                 Y4   775.    776.    777.    778.    779.    780.    781.    782.    783.    784.
   20                 Y4   785.    786.
   21                 Y5     0.      5.    57.5    58.5    60.8     62.     63.    64.5     66.    67.5
   22                 Y5   68.5    70.
   23                 $A6.33  7.23    26.21   60.56
   24                 $E775.  780.    790.    800.
   25                 $$775.
   26                 $D779.5
   27                 $L0.    62.     128.    286.    387.    504.    607.    630.    650.    675.
   28                 $V777.8 778.7   779.6   780.5   781.4   782.4   783.3   784.2   785.1   786.
   29                 K     99
```

RUN DATE(06/11/80.
TIME= 11.5F.17.

MISSOURI DAM INSPECTION PROGRAM
ST LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
ODD FELLOWS LAKE DAM

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
192	0	15	0	0	0	0	0	0	0
			JOPER	NWT	LROPT	TRACE			
			5	0	0	0			

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 7 LRTIO= 1

RTIOS= .05 .10 .15 .20 .25 .50 1.00

SUB-AREA RUNOFF COMPUTATION

ODD FELLOWS LAKE (48 HR. PROBABLE MAXIMUM RUNOFF)

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	3	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.76	0.00	.76	1.00	0.000	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	24.60	101.00	120.00	133.00	140.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOR	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-87.00	0.00	0.00

CURVE NO = -87.00 WETNESS = -1.00 EFFECT CN = 87.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= 1.49

RECESSION DATA
STRTQ= 0.00 QRCSN= 0.00 RTIOR= 1.00

UNIT HYDROGRAPH 32 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= 1.49 VOL= 1.00

18.	46.	94.	157.	205.	226.	226.	206.	179.	142.
104.	81.	63.	50.	39.	30.	23.	18.	14.	11.
9.	7.	5.	4.	3.	2.	2.	2.	1.	1.
0.	0.								

END-OF-PERIOD FLOW

0 MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q

RECESSION DATA

STRTQ= 0.00 QRCSN= 0.00 RTIOR= 1.00

UNIT HYDROGRAPH 32 END OF PERIOD ORDINATES. TC= 0.00 HOURS. LAG= 1.49 VOL= 1.00

18.	46.	94.	157.	209.	226.	226.	206.	179.	142.
104.	81.	63.	50.	39.	30.	23.	18.	14.	11.
8.	7.	5.	4.	3.	2.	2.	2.	1.	1.
0.	0.								

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.15	1	.00	0.00	.00	0.	1.02	.15	97	.04	.03	.01	9.
1.01	.30	2	.00	0.00	.00	0.	1.02	.30	98	.04	.03	.01	10.
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1.01	2.45	11	.00	0.00	.00	0.	1.02	2.45	107	.04	.04	.01	57.
1.01	3.00	12	.00	0.00	.00	0.	1.02	3.00	108	.04	.04	.01	60.
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1.01	7.15	29	.01	0.00	.01	0.	1.02	7.15	125	.19	.18	.01	144.
1.01	7.30	30	.01	0.00	.01	0.	1.02	7.30	126	.19	.18	.01	176.
1.01	7.45	31	.01	0.00	.01	0.	1.02	7.45	127	.19	.18	.01	209.
1.01	8.00	32	.01	0.00	.01	0.	1.02	8.00	128	.19	.18	.01	238.
1.01	8.15	33	.01	0.00	.01	0.	1.02	8.15	129	.19	.18	.01	265.
1.01	8.30	34	.01	0.00	.01	0.	1.02	8.30	130	.19	.18	.01	286.
1.01	8.45	35	.01	0.00	.01	0.	1.02	8.45	131	.19	.19	.01	302.
1.01	9.00	36	.01	0.00	.01	0.	1.02	9.00	132	.19	.19	.01	315.
1.01	9.15	37	.01	0.00	.01	0.	1.02	9.15	133	.19	.19	.01	325.
1.01	9.30	38	.01	0.00	.01	0.	1.02	9.30	134	.19	.19	.01	335.
1.01	9.45	39	.01	.00	.01	0.	1.02	9.45	135	.19	.19	.01	340.
1.01	10.00	40	.01	.00	.01	0.	1.02	10.00	136	.19	.19	.01	345.
1.01	10.15	41	.01	.00	.01	0.	1.02	10.15	137	.19	.19	.01	350.
1.01	10.30	42	.01	.00	.01	0.	1.02	10.30	138	.19	.19	.01	354.
1.01	10.45	43	.01	.00	.01	0.	1.02	10.45	139	.19	.19	.01	357.
1.01	11.00	44	.01	.00	.01	0.	1.02	11.00	140	.19	.19	.01	359.
1.01	11.15	45	.01	.00	.01	0.	1.02	11.15	141	.19	.19	.01	361.
1.01	11.30	46	.01	.00	.01	1.	1.02	11.30	142	.19	.19	.01	363.
1.01	11.45	47	.01	.00	.01	1.	1.02	11.45	143	.19	.19	.01	365.
1.01	12.00	48	.01	.00	.01	1.	1.02	12.00	144	.19	.19	.01	366.
1.01	12.15	49	.05	.01	.04	2.	1.02	12.15	145	.62	.61	.01	374.
1.01	12.30	50	.05	.01	.04	3.	1.02	12.30	146	.62	.61	.01	394.

1.01	10.[illegible]	46	.01	.00	.01	0.	1.02	10.00	136	.19	.19	.01	345.
1.01	10.[illegible]	47	.01	.00	.01	0.	1.02	10.15	137	.19	.19	.01	0.
1.01	10.30	42	.01	.00	.01	0.	1.02	10.30	138	.19	.19	.01	354.
1.01	10.45	43	.01	.00	.01	0.	1.02	10.45	139	.19	.19	.01	357.
1.01	11.00	44	.01	.00	.01	0.	1.02	11.00	140	.19	.19	.01	359.
1.01	11.15	45	.01	.00	.01	0.	1.02	11.15	141	.19	.19	.01	361.
1.01	11.30	46	.01	.00	.01	1.	1.02	11.30	142	.19	.19	.01	363.
1.01	11.45	47	.01	.00	.01	1.	1.02	11.45	143	.19	.19	.01	365.
1.01	12.00	48	.01	.00	.01	1.	1.02	12.00	144	.19	.19	.01	366.
1.01	12.15	49	.05	.01	.04	2.	1.02	12.15	145	.62	.61	.01	374.
1.01	12.30	50	.05	.01	.04	3.	1.02	12.30	146	.62	.61	.01	394.
1.01	12.45	51	.05	.01	.03	4.	1.02	12.45	147	.62	.61	.01	434.
1.01	13.00	52	.05	.01	.03	5.	1.02	13.00	148	.62	.61	.01	500.
1.01	13.15	53	.06	.02	.04	8.	1.02	13.15	149	.75	.73	.01	589.
1.01	13.30	54	.06	.02	.04	11.	1.02	13.30	150	.75	.74	.01	690.
1.01	13.45	55	.06	.02	.03	14.	1.02	13.45	151	.75	.74	.01	797.
1.01	14.00	56	.06	.03	.03	18.	1.02	14.00	152	.75	.74	.01	903.
1.01	14.15	57	.07	.03	.04	23.	1.02	14.15	153	.93	.92	.01	1007.
1.01	14.30	58	.07	.04	.03	27.	1.02	14.30	154	.93	.92	.01	1104.
1.01	14.45	59	.07	.04	.03	33.	1.02	14.45	155	.93	.92	.01	1195.
1.01	15.00	60	.07	.04	.03	38.	1.02	15.00	156	.93	.93	.01	1284.
1.01	15.15	61	.07	.04	.03	44.	1.02	15.15	157	.94	.94	.01	1372.
1.01	15.30	62	.15	.09	.05	51.	1.02	15.30	158	1.89	1.88	.01	1469.
1.01	15.45	63	.41	.29	.12	62.	1.02	15.45	159	5.29	5.27	.02	1636.
1.01	16.00	64	.10	.08	.03	77.	1.02	16.00	160	1.32	1.32	.00	1884.
1.01	16.15	65	.07	.05	.02	98.	1.02	16.15	161	.87	.87	.00	2217.
1.01	16.30	66	.07	.05	.01	122.	1.02	16.30	162	.87	.87	.00	2594.
1.01	16.45	67	.07	.05	.01	141.	1.02	16.45	163	.87	.87	.00	2872.
1.01	17.00	68	.07	.05	.01	152.	1.02	17.00	164	.87	.87	.00	2996.
1.01	17.15	69	.05	.04	.01	155.	1.02	17.15	165	.68	.68	.00	2987.
1.01	17.30	70	.05	.04	.01	152.	1.02	17.30	166	.68	.68	.00	2866.
1.01	17.45	71	.05	.04	.01	145.	1.02	17.45	167	.68	.68	.00	2687.
1.01	18.00	72	.05	.04	.01	135.	1.02	18.00	168	.68	.68	.00	2447.
1.01	18.15	73	.00	.00	.00	123.	1.02	18.15	169	.06	.06	.00	2196.
1.01	18.30	74	.00	.00	.00	113.	1.02	18.30	170	.06	.06	.00	1990.
1.01	18.45	75	.00	.00	.00	103.	1.02	18.45	171	.06	.06	.00	1787.
1.01	19.00	76	.00	.00	.00	92.	1.02	19.00	172	.06	.06	.00	1576.
1.01	19.15	77	.00	.00	.00	79.	1.02	19.15	173	.06	.06	.00	1353.
1.01	19.30	78	.00	.00	.00	67.	1.02	19.30	174	.06	.06	.00	1137.
1.01	19.45	79	.00	.00	.00	56.	1.02	19.45	175	.06	.06	.00	939.
1.01	20.00	80	.00	.00	.00	46.	1.02	20.00	176	.06	.06	.00	766.
1.01	20.15	81	.00	.00	.00	37.	1.02	20.15	177	.06	.06	.00	621.
1.01	20.30	82	.00	.00	.00	30.	1.02	20.30	178	.06	.06	.00	506.
1.01	20.45	83	.00	.00	.00	25.	1.02	20.45	179	.06	.06	.00	420.
1.01	21.00	84	.00	.00	.00	21.	1.02	21.00	180	.06	.06	.00	353.
1.01	21.15	85	.00	.00	.00	18.	1.02	21.15	181	.06	.06	.00	302.
1.01	21.30	86	.00	.00	.00	16.	1.02	21.30	182	.06	.06	.00	261.
1.01	21.45	87	.00	.00	.00	14.	1.02	21.45	183	.06	.06	.00	229.
1.01	22.00	88	.00	.00	.00	13.	1.02	22.00	184	.06	.06	.00	205.
1.01	22.15	89	.00	.00	.00	12.	1.02	22.15	185	.06	.06	.00	186.
1.01	22.30	90	.00	.00	.00	11.	1.02	22.30	186	.06	.06	.00	171.
1.01	22.45	91	.00	.00	.00	10.	1.02	22.45	187	.06	.06	.00	159.
1.01	23.00	92	.00	.00	.00	9.	1.02	23.00	188	.06	.06	.00	149.
1.01	23.15	93	.00	.00	.00	9.	1.02	23.15	189	.06	.06	.00	142.
1.01	23.30	94	.00	.00	.00	9.	1.02	23.30	190	.06	.06	.00	135.
1.01	23.45	95	.00	.00	.00	8.	1.02	23.45	191	.06	.06	.00	131.
1.02	0.00	96	.00	.00	.00	8.	1.03	0.00	192	.06	.06	.00	128.
									SUM	34.44	32.71	1.73	63320.
										(875.)(	831.)(	44.)(	1793.02)

PEAK 6-HOUR 24-HOUR 72-HOUR TOTAL VOLUME

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2996.	1851.	633.	329.	63256.
CMS	85.	52.	18.	9.	1791.
INCHES		22.63	30.97	32.22	32.22
MM		574.83	786.69	818.34	818.34
AC-FT		918.	1256.	1307.	1307.
THOUS CU M		1132.	1550.	1612.	1612.

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HYDROGRAPH ROUTING

ROUTING THROUGH SPILLWAY

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-775.	-1

STAGE	775.00	776.00	777.00	778.00	779.00	780.00	781.00	782.00	783.00	784.00
	785.00	786.00								
FLOW	0.00	5.00	57.50	58.50	60.80	62.00	63.00	64.50	66.00	67.50
	68.50	70.00								
SURFACE AREA=	6.	7.	26.	61.						
CAPACITY=	0.	34.	191.	613.						
ELEVATION=	775.	780.	790.	800.						

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
775.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
779.5	0.0	0.0	0.

CREST LENGTH	0.	62.	128.	286.	387.	584.	607.	630.	650.	675.
AT OR BELOW ELEVATION	777.8	778.7	779.6	780.5	781.4	782.4	783.3	784.2	785.1	786.0

STATION 2, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS						
				RATIO 1 .05	RATIO 2 .10	RATIO 3 .15	RATIO 4 .20	RATIO 5 .25	RATIO 6 .50	RATIO 7 1.00
HYDROGRAPH AT	1	.76	1	150.	300.	449.	599.	749.	1498.	2996.
	(	1.97)	(	4.24)(	8.48)(	12.72)(	16.96)(	21.21)(	42.41)(	84.82)(
ROUTED TO	2	.76	1	138.	293.	446.	597.	748.	1498.	2995.
	(	1.97)	(	3.87)(	8.31)(	12.62)(	16.92)(	21.18)(	42.42)(	84.81)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	775.00	775.00	779.50
STORAGE	0.	0.	30.
OUTFLOW	0.	0.	377.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.05	778.62	0.00	24.	108.	0.00	42.25	0.00
.10	779.31	0.00	29.	293.	0.00	41.25	0.00
.15	779.64	.14	31.	446.	1.50	41.25	0.00
.20	779.88	.38	33.	597.	2.75	41.25	0.00
.25	780.08	.58	34.	748.	3.50	41.25	0.00
.50	780.73	1.23	40.	1498.	6.25	41.25	0.00
1.00	781.54	2.04	47.	2995.	8.75	41.25	0.00

N
DAT